



Socio-economic background of wastewater irrigation and bioaccumulation of heavy metals in crops and vegetables

Shameem Raja^a, Hafiza Masooma Naseer Cheema^{a,*}, Shaista Babar^b, Asif Ali Khan^a, Ghulam Murtaza^c, Usman Aslam^a

^a Plant Genetic Resources Lab, Department of Plant Breeding and Genetics, University of Agriculture, Faisalabad, Pakistan

^b Department of Home and Health Sciences, Allama Iqbal Open University, Islamabad, Pakistan

^c Institute of Soil and Environmental Sciences, University of Agriculture, Faisalabad, Pakistan

ARTICLE INFO

Article history:

Received 2 June 2014

Accepted 13 April 2015

Available online 14 May 2015

Keywords:

Peri-urban agriculture

Industry effluents

Health hazards

Poverty

ABSTRACT

Water scarcity is one of the main constraints for agriculture sector in many countries. It pushes the farmers to use wastewater for irrigation as an available alternate, especially in peri-urban areas of developing countries. One of the drawbacks of using wastewater for irrigation is heavy metal pollution in the soil and water along with the toxic elements which enter into the food chain. This study aims at to obtain information about the socio-economic reasons for using wastewater from the farmers' perspective and analyze the accumulation of heavy metals in wastewater, canal water, underground water, soil and crops, irrigated with wastewater. Two contrasting views were observed among the farmers about wastewater irrigation. Over 90% preferred to use wastewater due to its low cost and rich source of nutrients. Although, farmers know that wastewater irrigation have serious negative effects on human health and the quality of the ground water, they prefer to use it for lowering the cost of production and overcome the scarcity of canal water. The findings of this study showed that, ground water and canal water have more accumulation of Cr, Mn, Pb and Zn than the recommended safe limits. None of the water samples collected from different sources was found to be safe for irrigation due to heavy metal contamination. Wastewater irrigated crops and vegetables were also analyzed to determine the bioaccumulation of heavy metals. Concentrations of Cr, Mn, Pb and Zn were observed more than safe limits in all the analyzed vegetables (spinach, cabbage, cauliflower, mustard leaves and round gourd) and crops (berseem, sorghum, maize, rice, wheat, lucerne, sugarcane). This study showed that poor economic conditions force the farmers to not only sacrifice their own health but also the health of consumers of these crops and vegetables by using wastewater for irrigation.

© 2015 Elsevier B.V. All rights reserved.

1. Introduction

Water scarcity is a critical problem for crop production in dry areas all over the world. Where water is scarce, wastewater is often used for irrigation. This practice was first reported in Melbourne, Australia, where sewage farms were established in 1897 (Shuval, 1990). In Pakistan two main sources of water are used for irrigation: canal and ground water. Due to increasing scarcity of canal water, the dependency on groundwater has increased but groundwater is expensive and largely of poor quality due to high electrical conductivity (EC), sodium adsorption ratio (SAR), residual

sodium carbonate (RSC) and heavy metals (Murtaza et al., 2008). As a consequence, wastewater has become one of the main sources of water for irrigation. In developing countries, about 80% of the generated wastewater is used for irrigation (Mara et al., 1989; Cooper, 1991). Worldwide, 20 mha in 50 countries is irrigated with urban wastewater (Scott et al., 2004). In Pakistan about 30% of wastewater is directly used to irrigate around 32,500 ha (Ensink et al., 2004), while 64% is discharged into rivers without any treatment (FAO, 1992). It has been estimated that out of the total wastewater produced in Pakistan, <8% is treated only at primary level through sedimentation, while only 1% is treated with bacterial digestion of organic matter (Pak-SCEA, 2006). Wastewater usage for irrigation has the benefits of conserving water and nutrients, reducing the pollution of rivers and canals, providing micronutrients, organic matter, all required nitrogen, and much of the required phosphorus and potassium for normal crop production (FAO, 1992; Murtaza

* Corresponding author. Tel.: +92 0419200032.

E-mail addresses: masooma@uaf.edu.pk, masoomasj@gmail.com (H.M.N. Cheema).

et al., 2010; Hanjra et al., 2012). It is a great temptation for the poor farmers to use wastewater as it can reduce the crop production cost by 10–20%. Besides these advantages, wastewater application has a number of drawbacks including the contamination of groundwater, build-up of heavy metals and organics in the soil and the creation of habitat for harmful microorganisms (Mapanda et al., 2007; Murtaza et al., 2010; Qadir et al., 2010).

Previous studies pointed out that the main drawback of wastewater application is the presence of heavy metals (Henze et al., 2002) and their potential bioaccumulation. These heavy metals enter the food chain and can result in a number of disorders to human health when concentrations exceed the safe limits (Martin and Griswold, 2009). The alleviation policies to reduce heavy metal exposure through food are usually overlooked (Sharma et al., 2014). Opinions are divided about the value of wastewater for irrigation. Some studies found that wastewater irrigation for 8–10 years did not salinize the fields (Abdul et al., 2001) and being the only available source for irrigation, its application was not recommended to be banned. The opponents claim that the use of wastewater is an act of criminal negligence and due to its fatal health effects, it should be banned (Feenstra et al., 2000).

Metal movement into the ground water occurred through soil water; however some of the factors like adsorption, precipitation, amount and type of clay, reactive oxide minerals, organic matter and number of micropores reduce the movement of metals into ground water. Downhill movement of metals occurred when heavy metal holding capacity in soil is overloaded. Similarly metal movement is determined by the soil type, concentration of metals, pH, cation exchange capacity of soil, concentration and kind of competing ions, organic and inorganic material and redox status (De Matos et al., 2001; Olaniran et al., 2013). Main factors which enhance the mobility of metals are the soil texture, fissures and cracks. The sand and silt allow more movement of water and contaminants while in fine textured soil, movement of water and contaminants is negligible. Possessing all properties of clay and sandy loam type soil, the soil of study area, allows the movement of water and metals (McLean and Bledsoe, 1992).

In peri-urban areas of Pakistan, wastewater is frequently used without any prior treatment to irrigate vegetables and crops due to non-availability of fresh water (Murtaza et al., 2010; Qadir and Ghafoor, 1997). Farmers are usually not well informed about the drawbacks of this practice, and have a different opinion (Zafar and Akhtar, 2003). About 26% of all vegetables grown in Pakistan are irrigated by untreated wastewater. As a result, locally produced vegetables are about 60% cheaper than imported vegetables, due to lower costs for fertilizer and transportation to markets (Ensink et al., 2004; Hanjra and Qureshi, 2010).

This study was planned to answer the following questions: (i) why farmers opt to irrigate with wastewater? (ii) How much concentration of heavy metals in underground water, wastewater, and canal water does exist? (iii) Does variability of heavy metal concentration exist among different crops irrigated with wastewater in their uptake and accumulation?

2. Materials and methods

A survey was conducted in peri-urban area of Faisalabad (Uchkara) to collect information about farmer's perception about socio-economic background of wastewater use for agriculture. Untreated wastewater is used to irrigate 10,000 ha in the study area having a population of 12,000 (Mahmood and Maqbool, 2006). For survey a questionnaire was developed which included questions related to impacts of wastewater on financial status, social set up, health status, quality and usage of underground water, yield and quality of crops, fodders/vegetables, source of water for irrigation

and drinking, reasons for preference and cropping pattern. Quar-tile method of survey was adopted for data collection (Vasconcellos and Anjos, 2003).

2.1. Soil, water and plant sampling

Analysis of soil, wastewater, underground water, canal water and crops grown in study area were conducted to determine the concentration of heavy metals. Soil was sampled from two depths; upper layer (0–20 cm) and lower layer (20–40 cm), of Uchkara and UAF area. The concentration of metals was determined separately from grains and shoots of wheat and rice crops. Edible part of food/fodder crops were freshly harvested from three farms, washed with distilled water and packaged into paper bags (Fig. 1) (Abdullahi et al., 2007). Wastewater used for irrigation in Uchkara (WW-U), University of Agriculture Faisalabad (WW-UAF), canal water (CW) and underground water (UGW) samples were collected in plastic bottles from three sites. Wastewater available in UAF was the water which was discharged from different industries, hospitals, houses, commercial buildings and etc.

2.2. Sample preparation

The collected plant samples were sun dried for 3–4 days then oven dried at 80 °C until the samples were completely dried and ground in an electrical grinder machine. These ground samples were passed through sieve to separate large particles and to get fine powdered material. One gram sample of each crop and vegetable in triplicate was transferred to 250 mL conical flask. In each sample, 5 mL nitric acid and 5 mL perchloric acid were added and kept overnight. In these samples, 5 mL nitric acid was added next day and digested on hot plate until the brown vapors were converted into colorless fumes. When brown fumes were turned into colorless fumes a colorless liquid sample was obtained. These colorless samples were stored in plastic bottles and volume was made up to 50 mL by distilled water (Miller, 1998; Singh et al., 2012).

For water sample preparation 100 mL of water sample was taken in 250 mL conical flask with the addition of 5 mL of nitric acid and 5 mL of perchloric acid and kept overnight at room temperature. Next day, 5 mL of nitric acid was added and digested on hot plate. Concentrations of heavy metals from water and plant samples were determined by flame atomic absorption spectrophotometer (Hitachi Polarized Zeeman Model) as described by (Singh et al., 1999).

2.3. Soil properties

Soil texture and chemical parameters, i.e. saturated soil paste pH (PH_s), electrical conductivity of saturated soil paste extract (EC), cation exchange capacity (CEC), organic matter, calcium carbonate (CaCO₃), iron (Fe), manganese (Mn), zinc (Zn), chromium (Cr), lead (Pb), nickel (Ni) were determined by the protocol as described by Ryan et al. (2007). The soil belongs to Coarse loamy, mixed, Hyperthermic, Typic Haplocambids according to USDA soil taxonomy classification.

2.4. Heavy metal balance

Heavy metal balance was determined for each field based on heavy metals input sources and their accumulation in the soil and crop after leaching down. Heavy metal balance was determined for each crop as well as for each metal. The metal balance was determined by the following equation:

Heavy metal balance

$$= [(HMIW + HMNS + HMF) - (HMIS + HMC)] \quad (1)$$

Download English Version:

<https://daneshyari.com/en/article/4478418>

Download Persian Version:

<https://daneshyari.com/article/4478418>

[Daneshyari.com](https://daneshyari.com)